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Title: Thermal Studies of HMX Decomposition

Author(s): Salinas, Daniela Evodia

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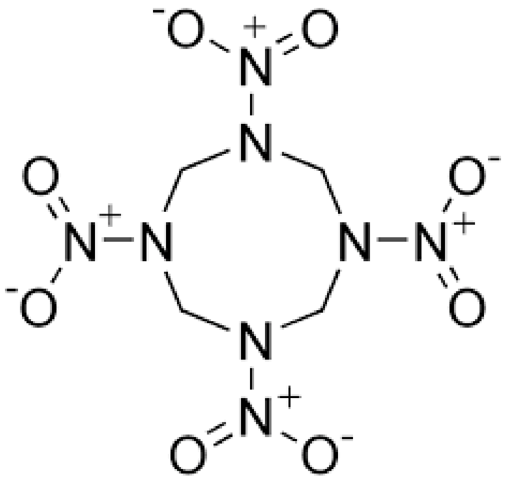
THERMAL STUDIES OF HMX DECOMPOSITION

W-10,WEAPONS RESPONSE CPCS, PHYSICAL CHEMISTRY AND APPLIED SPECTROSCOPY

DANIELA SALINAS

HMX

- $C_4H_8N_8O_8$
- Powerful insensitive nitroamine high explosive
- Detonator in nuclear weapons
- HMX most effective chemical explosive
- High melting point and molecular weight



OBJECTIVE

- Understand the kinetics of the HMX decomposition process
- Isothermal tests at a new temperature range 205°C-280°C
- Contribute to the global chemical kinetic model of HMX high explosive (Henson)

TG/DSC METHODS

- Thermogravimetric/ Differential Scanning Calorimetry
- STA 409 PC Instrument
- Simultaneously measures weight change and heat flow

TG/DSC METHODS

Run a baseline measurement

Measurement Type: ‘Correction’

↓

Calibration measurement with sapphire

Measurement Type: ‘Sample+Correction’

↓

Sample measurement

Measurement Type: ‘Sample+Correction’

OPEN AND CLOSED PANS

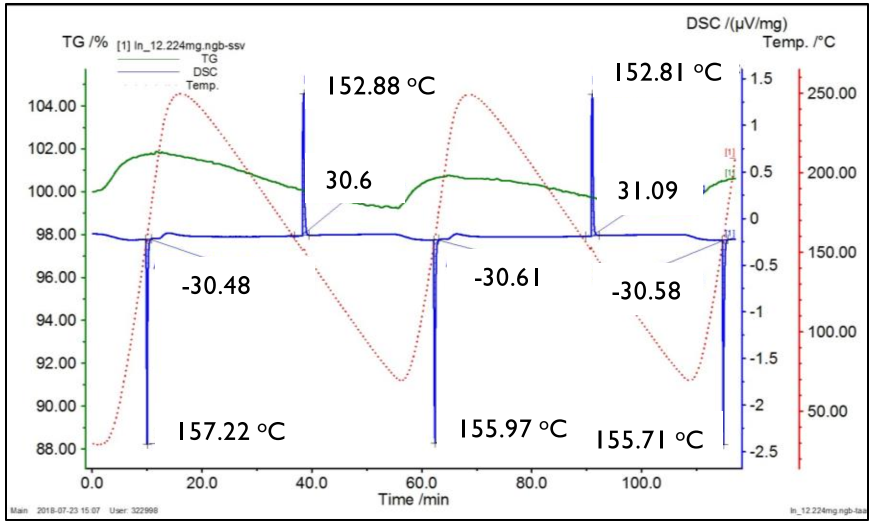
- Open
  - Decomposition reaction characteristics
  - Deflagration and detonation processes
- Closed
  - Confined spaces
  - Secondary reactions
  - Accelerated decomposition reactions

TEMPERATURE PROGRAM

- Initial (25°C)
- Dynamic (10°C/min)
- Isothermal (205°C-285°C)
- Final (+20°C)
- Final Standby/ Emergency (+20°C)

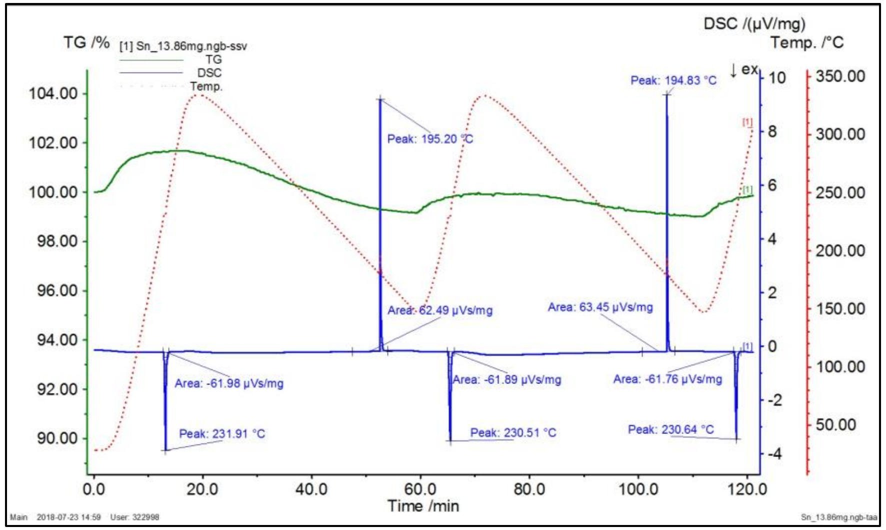
- NETZSCH Proteus Analysis
  - Temperature Calibration
  - Sensitvity Calibration
  - Sensitivity Calibration via Cp

INDIUM, TIN, ZINC

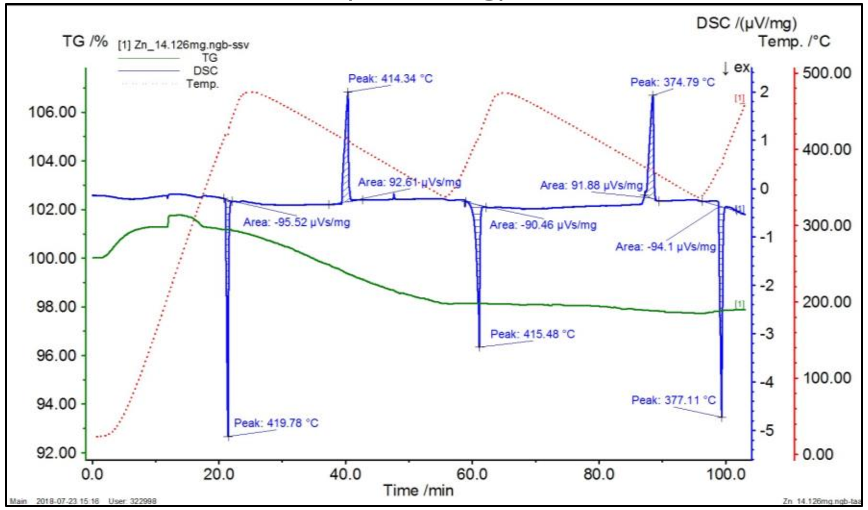


Endothermic and Exothermic Peaks
Melting and Recrystallization

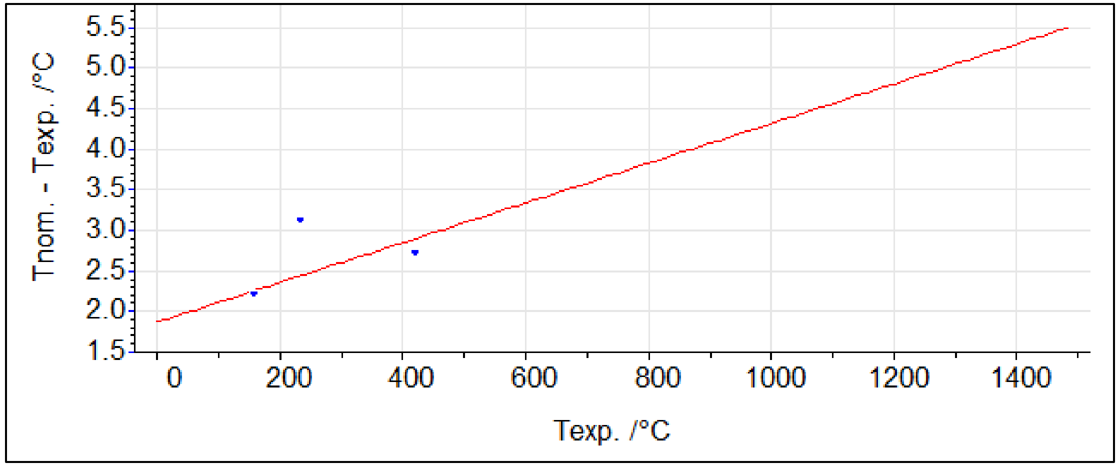
Area under the curve
specific enthalpy of fusion
(µVs/mg)



Hysteresis can be observed

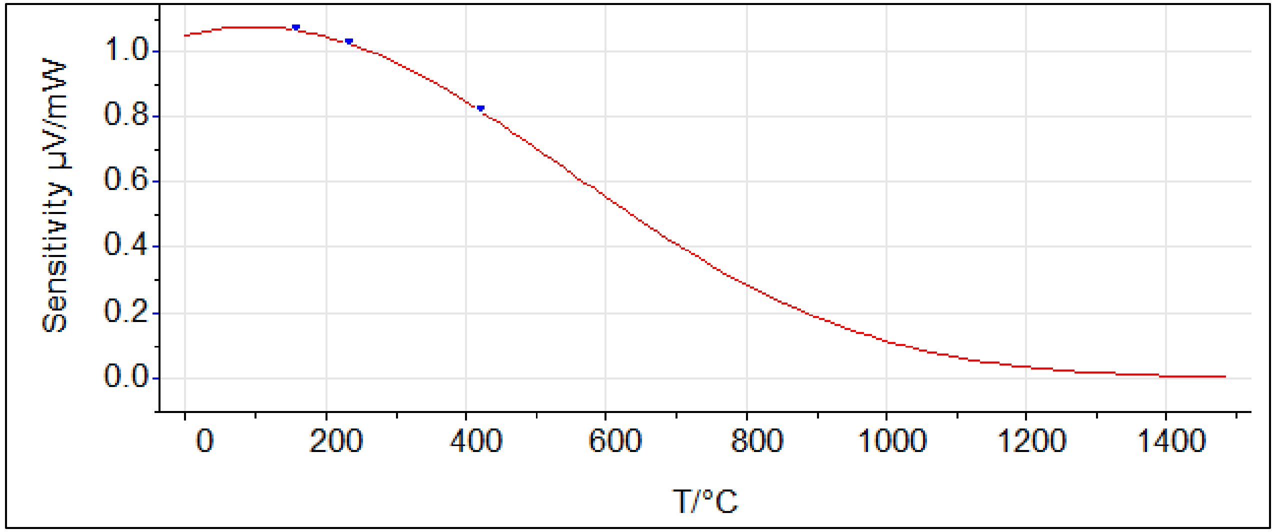


CALIBRATIONS

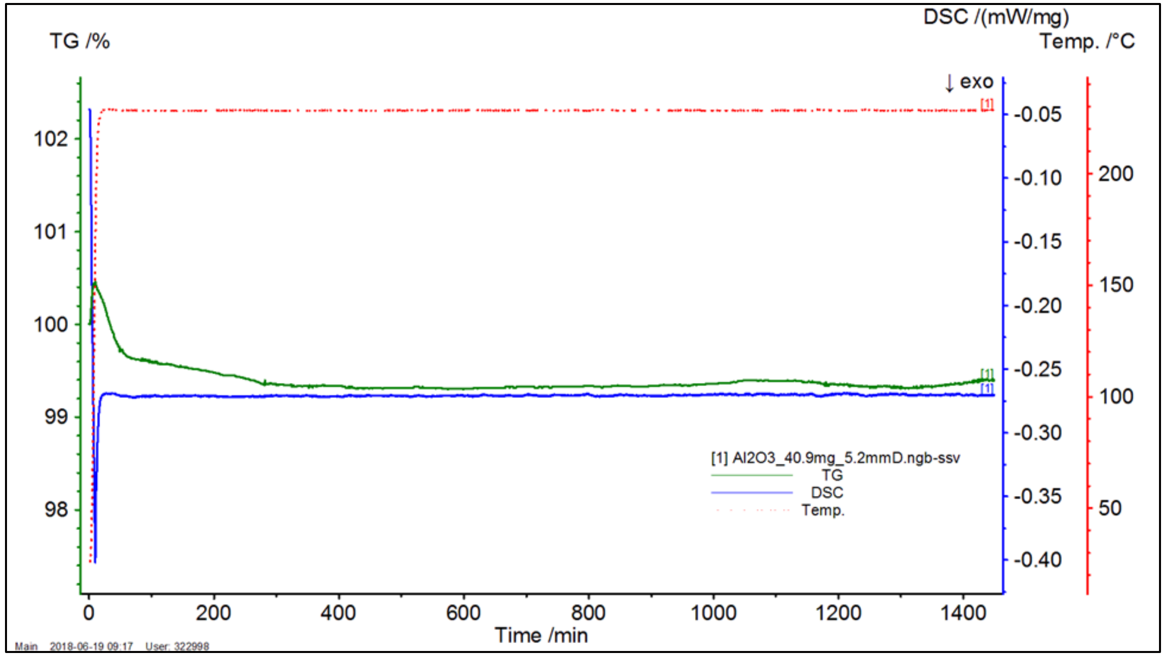


Temperature Calibration: In, Sn, Zn

Sensitivity Calibration Curve: In Sn, Zn

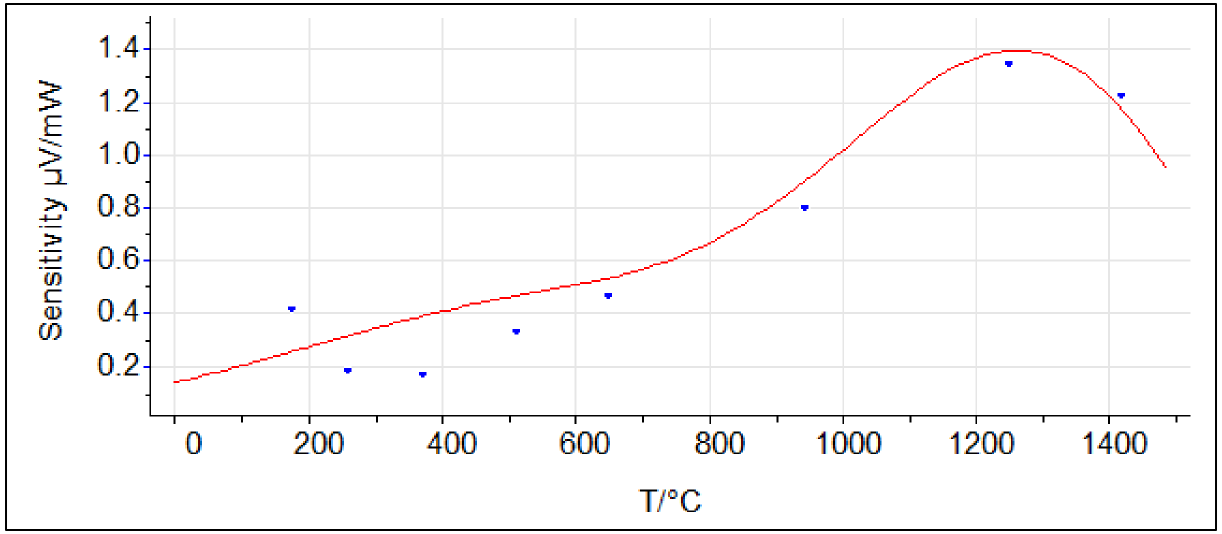


CALIBRATIONS



Baseline Stability for Sapphire

Sensitivity Calibration via Cp

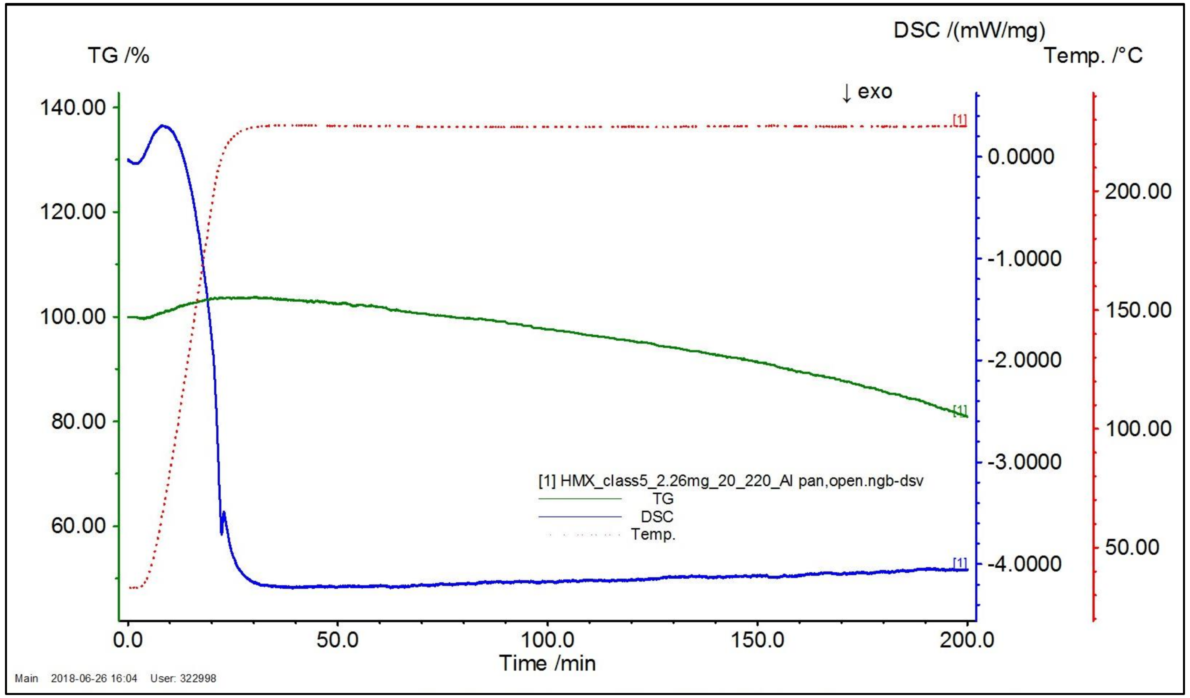


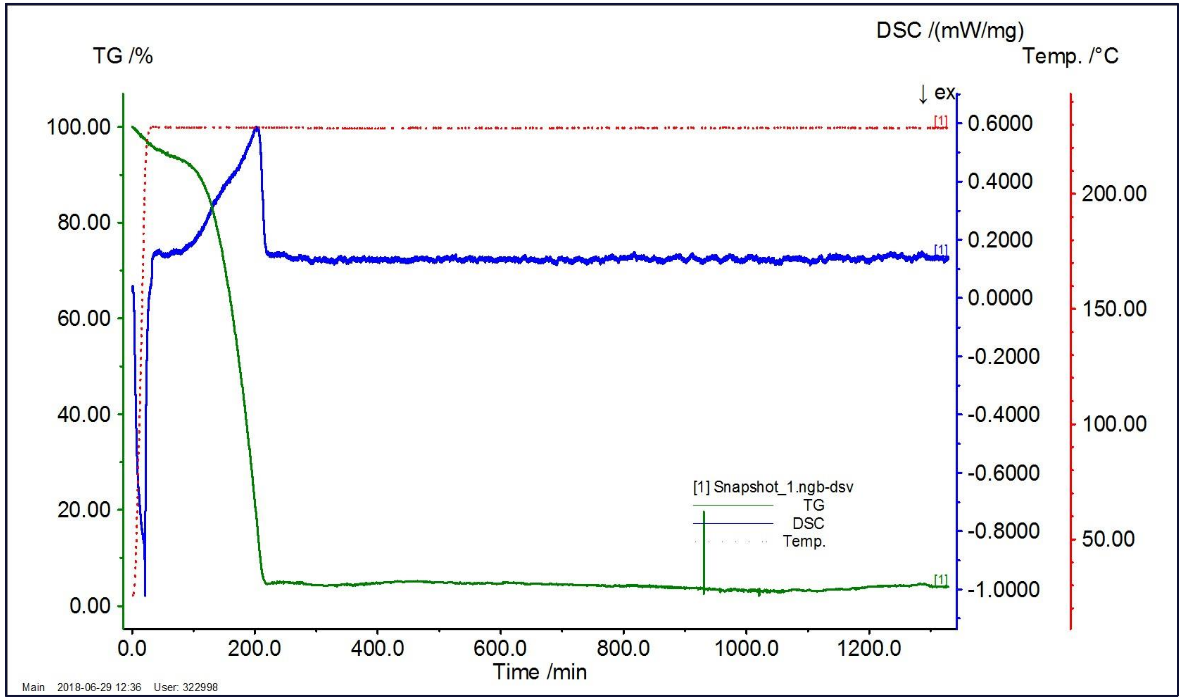
EXPERIMENTS

- Isothermal tests
  - 2-3mg HMX samples
  - 280°C, 270°C, 220°C, 210°C, 205°C
  - Constant heating rate, 10°C/min
  - Aluminum pans
  - Nitrogen atmosphere

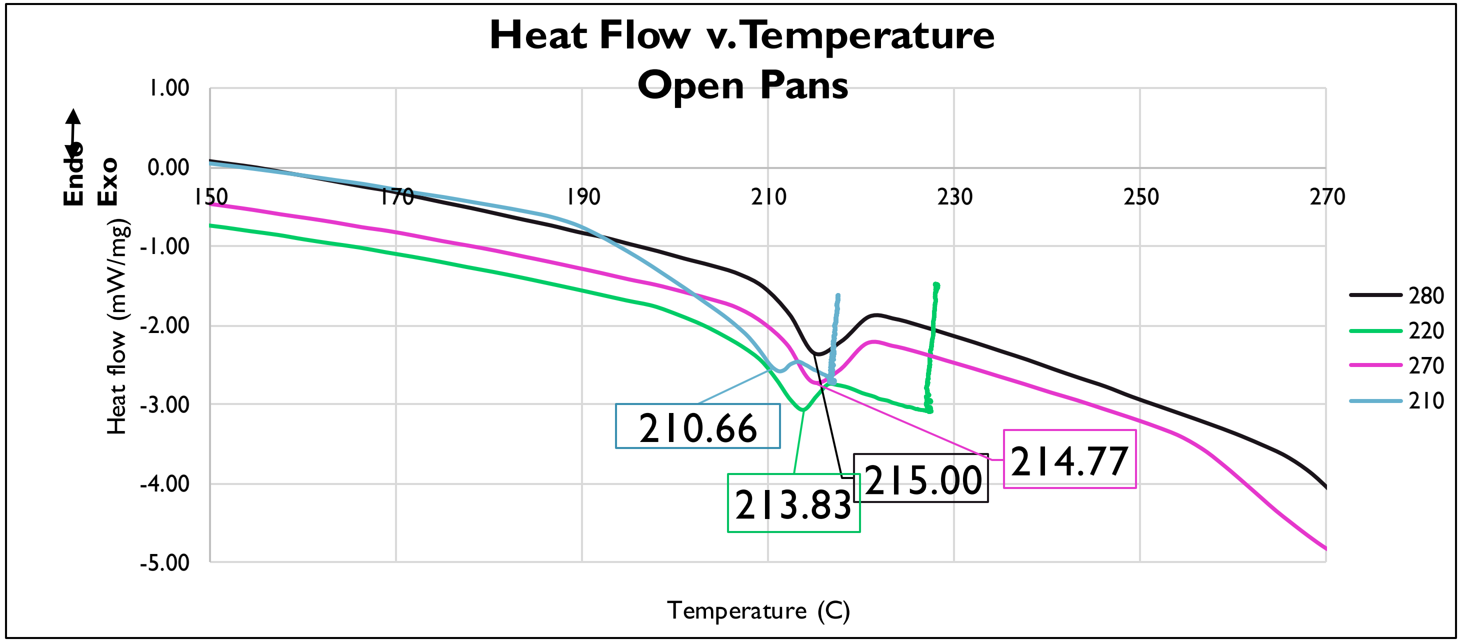
OPEN AND CLOSED ALUMINUM PANS

220^{O}C ISOTHERM

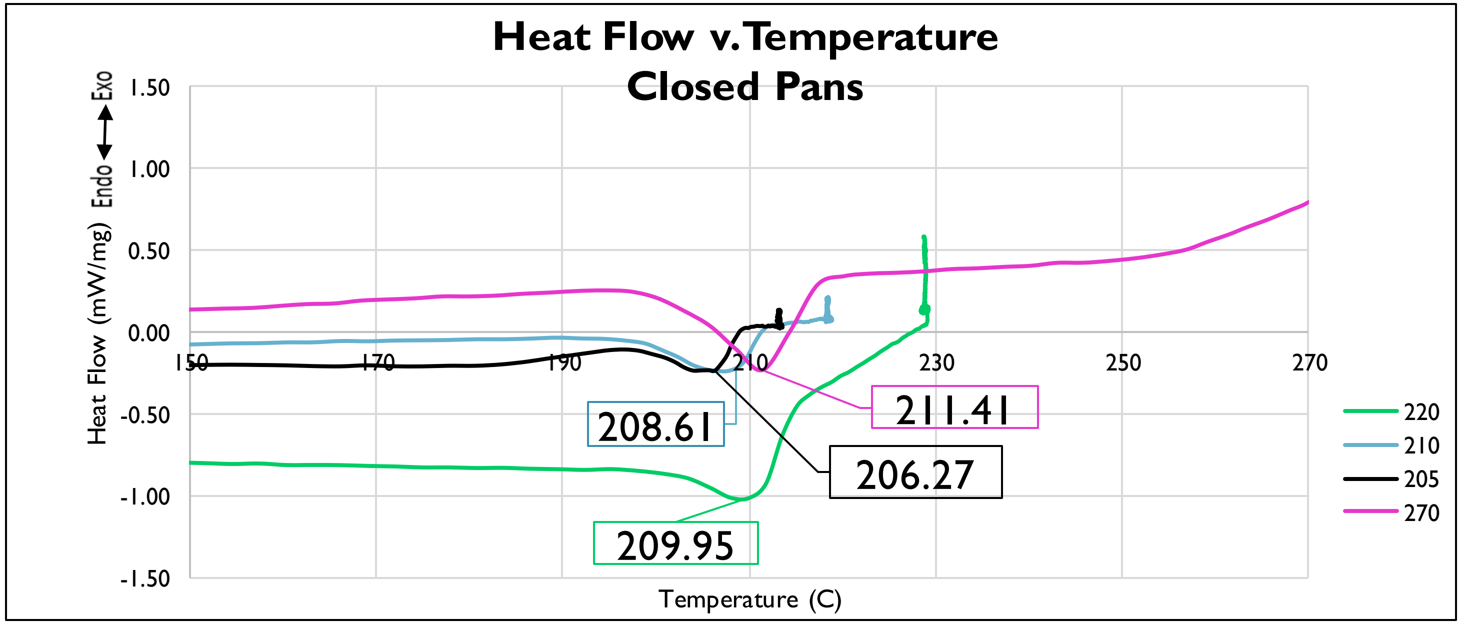




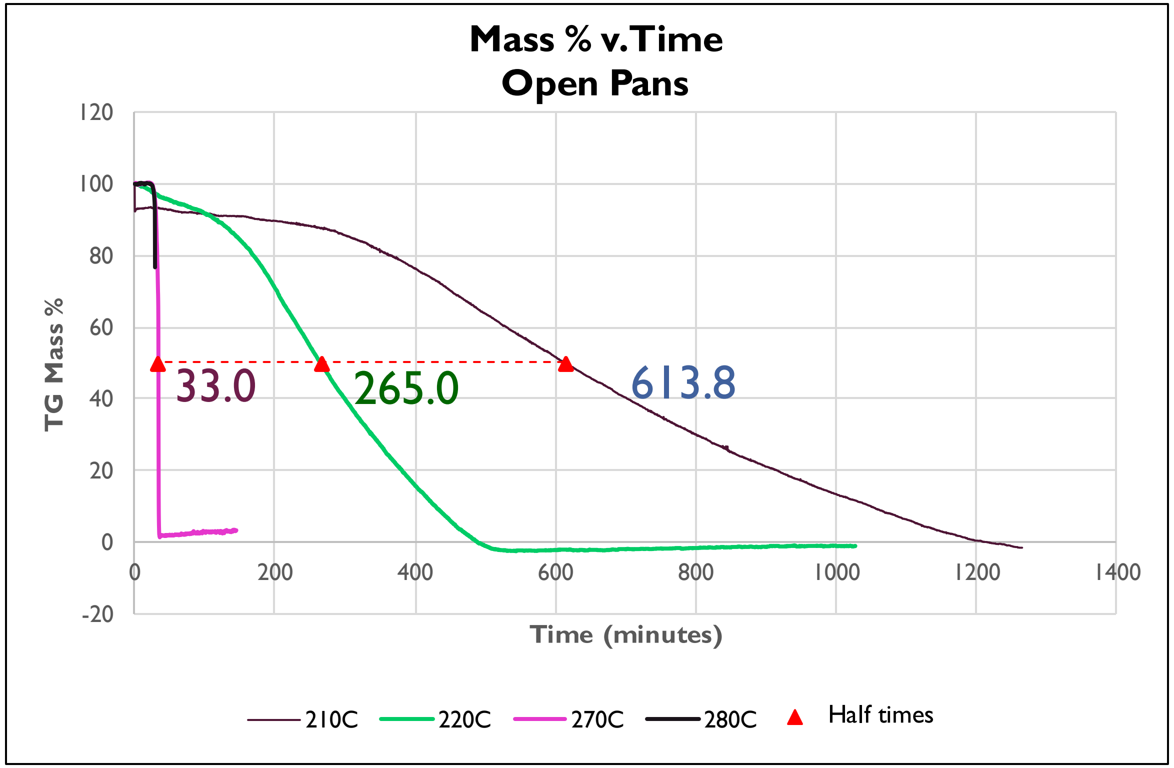
Open and closed pan 2-3mg samples, 220^{o}C isotherm for 24 hours, 10^{o}C/min heating ramp

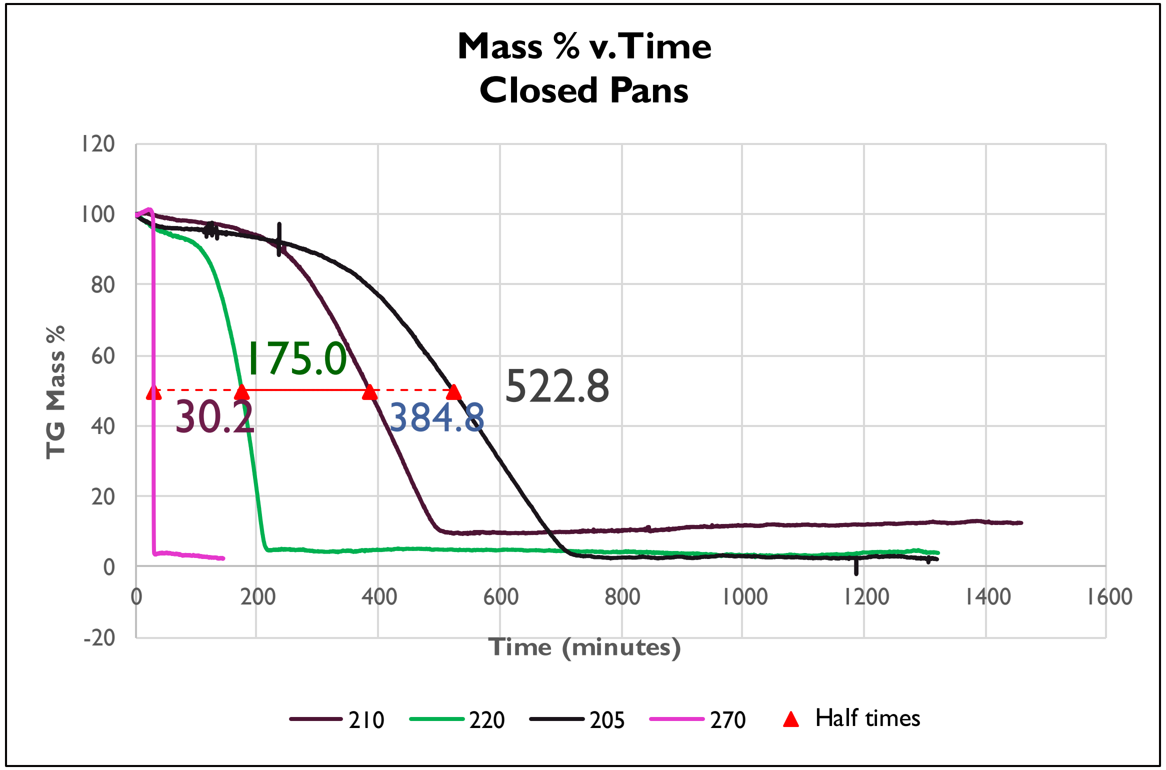


Heat Flow v. Temperature
Open Pans
Endo
Exo
Heat flow (mW/mg)
1.00
0.00
-1.00
-2.00
-3.00
-4.00
-5.00
150
170
190
210
230
250
270
Temperature (C)
280
220
270
210
210.66
213.83
215.00
214.77

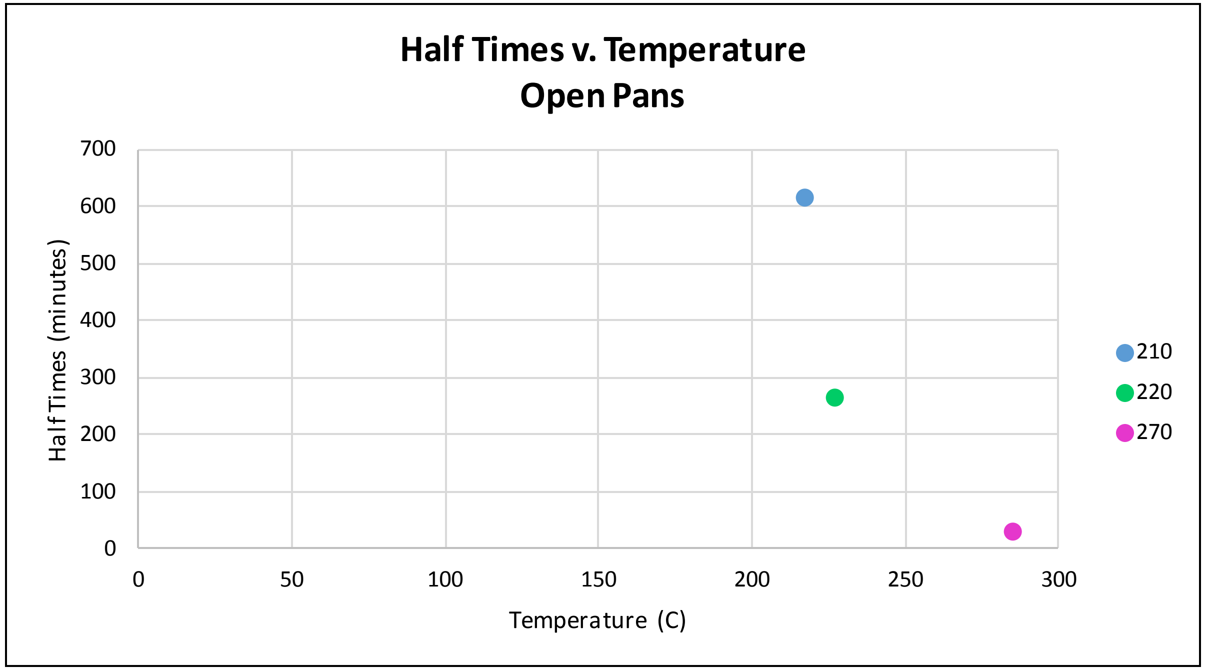


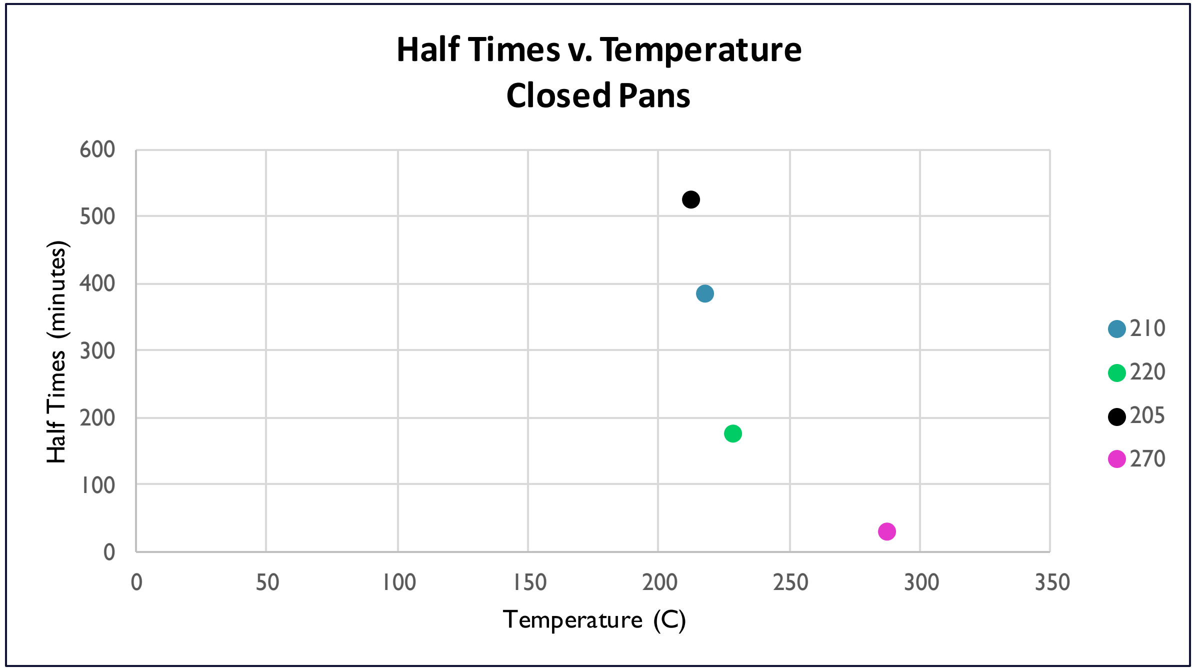
Heat Flow v. Temperature
Closed Pans
Exo
Endo
Heat Flow (mW/mg)
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
150
170
190
210
230
250
270
Temperature (C)
220
210
205
270
208.61
211.41
206.27
209.95

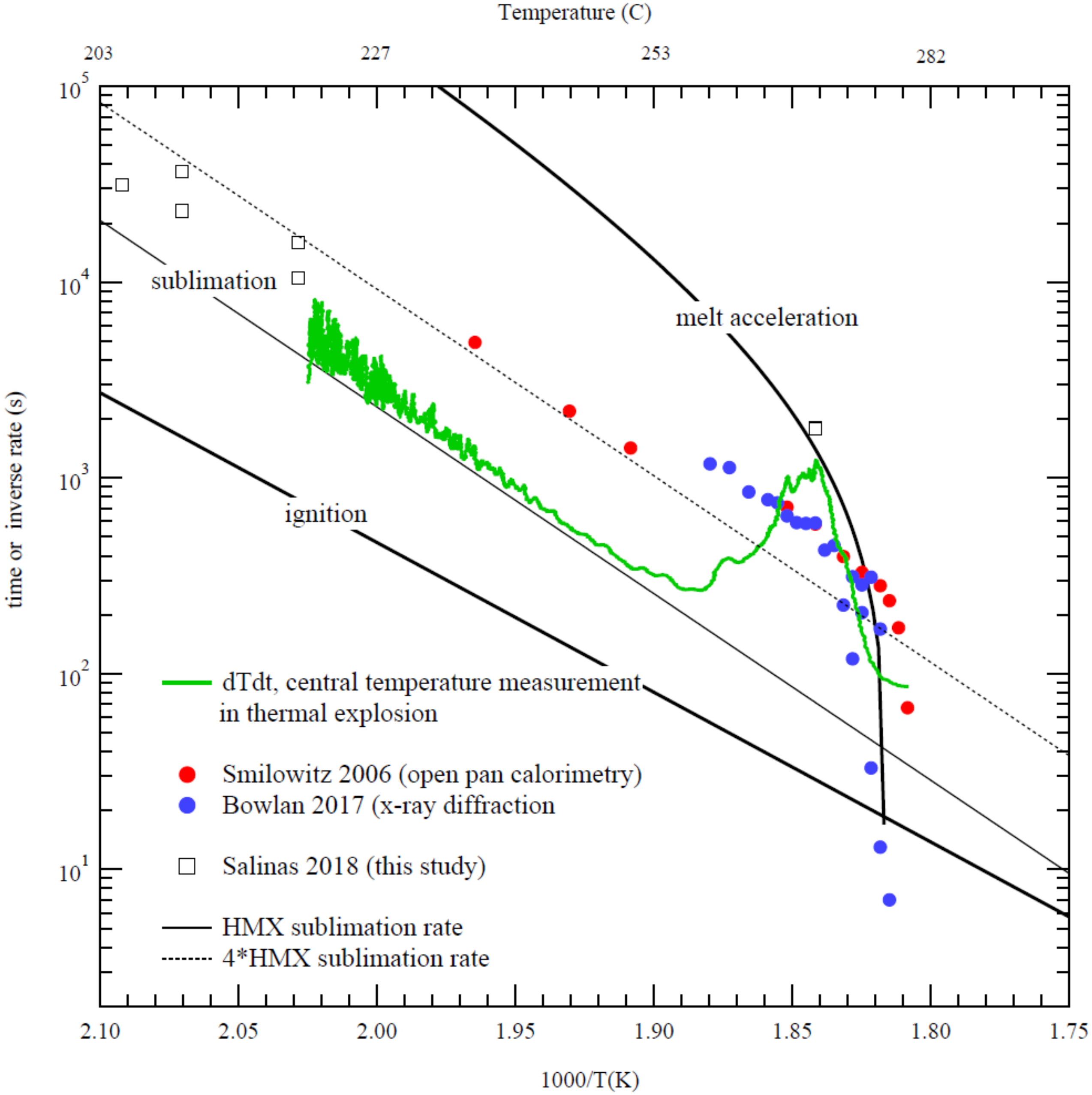




TG curves of %mass loss over time


Half Times v. Temperature
Open Pans
Half Times (minutes)
Temperature (C)
0
50
100
150
200
250
300
100
200
300
400
500
600
700
210
220
270


Half Times v. Temperature
Closed Pans
Half Times (minutes)
Temperature (C)
0
50
100
150
200
250
300
350
100
200
300
400
500
600
210
220
205
270



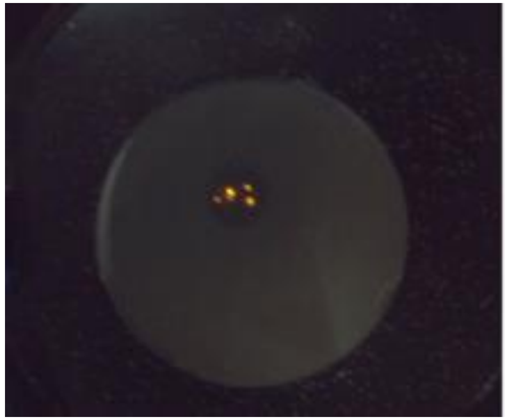
Time to ignition and reaction kinetics global chemical HMX model with different observables
See: Henson and Smilowitz, IDS, (2010)

CONCLUSION

- Absorbing heat and losing mass for open (210°C-215°C) and closed (206°C-211°C) pans
- Half times 200°C-300°C range for open and closed pans
- Temperature range follows the linear trend for the global chemical kinetic model for HMX

FUTURE WORK

- Repeat experiments to identify impurities
- Preheat the furnace for an “instantaneous heating effect”
- PETN and TATB experiments



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- [2]Henson, B.F., et al. Evidence for Thermal Equilibrium in the Detonation of HMX. Shock Wave Science and Technology Reference Library, Vol. 5.
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